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Smallholder farmers' perception to climate change impact on crop production: Case from drought prone areas of Bangladesh

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Abstract Agriculture sector, due to its sensitivity, is vulnerable to climate change and it experiences several extreme climatic events such as droughts, flooding, natural catastrophes and salinity intrusion. Coping climate change events and mitigating its impacts on crop production need to assess farmers' perception. The purpose of the study was to assess smallholder farmers' perception to climate change impact on crop production in drought prone areas of Bangladesh. Mixed methods approaches including quantitative and qualitative data were employed. Primary data were collected using a structured questionnaire through household survey during September and October 2017. The study respondents were 100 smallholder farmers in the drought prone areas of Bangladesh. The data were analysed using descriptive statistics, coefficient of correlation and stepwise regression. The major findings reveal that the perceived impacts of climate change on crop production was severe followed by moderate impact. Among twelve statements regarding climate change impact on crop production, increased pest infestations was perceived as most important impact. Increased frequency of drought occurrences was perceived as second most important impact of climate change. However, the least important impact of climate change was increased intensity of floods. Among the socio-economic characteristics of the respondents, age, year of schooling, farming experience, access to information sources and training experience were significantly associated with their perception to climate change impacts on crop production. In addition, year of schooling, farming experience and training experience were the most influential factors that affected smallholder farmers' perception. The study identified important issue for the policy makers and other development practitioners to address and to recommend suitable programs. The methods employed in and the findings of this study could be used in other districts of Bangladesh with similar socio-economic and regional context.

Keywords: climate change, smallholder farmer, drought, impact, crop production

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Introduction

Climate change is one of the key challenges to agricultural development and livelihood conditions in the developing country like Bangladesh (Rakib and Anwar, 2016). Climate change apparently is the change within the mean values of climate measure by component such as; rain, temperature, over a long period, typically fifty years. Climate change is the important change within the state of climate of an area that may be known by change within the mean associated or within the variability of its properties that persist for an extended period ineffably decades or longer (IPCC, 2012). It causes negative impacts on crop production (Below *et al*., 2010). Due to the size and sensitivity of the agricultural sector, the impact is relatively high in developing countries (IPCC, 2014). According to Bosello and Zhang (2005) that climate change and agriculture possess a complex and manifold relationship. The poor people, living in a developing and densely populated country like Bangladesh, are at severe risk due to climate change. Bangladesh is one of the top most nations vulnerable to climate change (Harmeling, 2008). In Bangladesh, agriculture sector plays a significant role to the national gross domestic products (GDPs) (17 percent; source: BBS, 2013) and it is the main income source of about 46 percent total labour force (Labor Force Survey, 2010).

Drought is a natural hazard that occurs due to prolonged insufficiency in water availability (Padhee, 2013). A significant part, especially northwestern and southwestern parts of Bangladesh, is vulnerable to drought conditions. The National Water Management Plan (NWMP) stated drought occurrences as a major water deficiency related issue in northwest region of Bangladesh (WARPO, 2001). Attributes such as moisture retention capacity and infiltration indicate the prevalence of droughts in northwest region of Bangladesh. Droughts are regional events and their occurrences are governed by regional climatic parameters like precipitation, evaporation and temperature. Therefore, the characteristics and consequences of drought vary from one to another climatic region.

In Bangladesh, drought is considered as the main cause that impedes the estimated crop production over the last few decades (Dey *et al*., 2011). FAO (2008) predicted that rainfall may decrease by 37 percent in dry season leading to increasing droughts frequency. The impact of drought observed in the form of a decrease in food production through a decrease in cultivated area and crop yield. Drought adversely effects all three rice seasons (*Aus*, *Aman* and *Boro*) in Bangladesh. It also causes damage to jute and other crops such as pulses, potatoes, oilseeds, minor grains, winter vegetables and sugarcane (Adnan, 2003). Depending on the intensity of drought, estimated crop yield reduction of

different crops varies from 10 to 70 percent (Adnan, 2003). Yield reductions due to severe droughts vary from 45 to 60 percent in transplanted *aman* and 50-60 percent in *rabi* crops. Rahman *et al*. (2007) reported that total crop production was reduced by 30-40 percent in the north-western part of the country in 2006. Saha *et al.* (2013) and Miyan (2015) reported that drought in 1951 affected severely in north-west regions of Bangladesh substantially reducing rice production.

Smallholder farmers occupy the major part of the farming communities in Bangladesh. They are typically attributed as low land holdings (usually 0.21 - 1.0 hectare of lands), poor, large family size and probably most vulnerable to climate change (FAO, 2015). The farming communities in the northwest region of Bangladesh experience frequent droughts resulting from climate change (Mardy *et al*, 2018). Reduced and uneven rainfall lead the region to drying up of surface water bodies such as ponds, lakes, beels, and in addition groundwater table become low due to overexploitation of irrigation water for crop production (Dey *et al*., 2011). Due to their characteristics mentioned earlier, smallholder farmers experience impacts of climate change on crop production significantly. Adaptation to climate change is a global concern (Alam, 2015; Elum *et al*., 2017) and the farming communities of Bangladesh are also practicing coping strategies to climate change (Arfanuzzaman *et al*., 2016). Adaptation to climate change by the farmers needs to consider their perception on it. Perception refers to the process concerned with the acquisition and interpretation of information from one's environment (Maddox, 1995). Howlader *et al*. (2015) stated that perception is the preliminary stage to adaptation towards climate change. To better cope up and adopt strategies, it is the principal need to determine the perception of smallholder farmers' on climate change in drought prone areas of Bangladesh. A number of researches regarding farmers' perception on climate change (Rakib and Anwar, 2016; Kamruzzaman, 2015), farmers' perception and agricultural adaptation (Islam and Hossen, 2016), determinants to farmers' perception to climate change (Uddin *et al*., 2017) have been conducted so far. In addition, few studies on smallholder farmers' perception to climate change (Panda and Singh, 2016; Munthali *et al*., 2016; Kalungu *et al*., 2013; Nyanga *et al*., 2011) have been conducted in India, Malawi, Kenya, and Zambia, respectively. However, existing literature do not show enough information regarding smallholder farmers' perception to climate change impact, especially on crop production in Bangladesh. Therefore, the present study was considered to focus on the mentioned issue.

Objectives: The study was to determine smallholder farmers' perception to climate change impact on crop production in the drought prone areas of Bangladesh.

Materials and methods

Study area

The study was conducted in two sub-districts, namely, Domar and Kishoreganj of Nilphamari district (Figure 1). The sub-districts were selected purposively in consultation with the experts for the research purpose. The area of Nilphamari district is 1580.85 sq km, which is located in between 25°44' and 26°19' north latitudes and in between 88°44' and 89°12' east longitudes. The district is surrounded by West Bengal state of India on the north, Rangpur district on the south, Lalmonirhat district on the east, Panchagarh and Dinajpur districts on the west (Banglapedia, 2018). Climatic characteristics of this district indicate low amount of rainfall, high rate of evapotranspiration and lower groundwater table resulting in severe water scarcity. Around 68.51 percent of the people depend on agriculture for their income and livelihood (Banglapedia, 2018). The major agricultural crops are rice, wheat, jute, pulse, oilseed, vegetable, spice, sugarcane, and tobacco. Among rice growing seasons, aman occupies the largest area followed by aus and boro (BBS, 2011). However, due to unavailability of surface water sources and inadequate amount of rainfall, the smallholder farmers need to rely on groundwater sources for crop production and other usages.

Study design

The study was based on a cross- sectional survey data from smallholder farming households across two sub-districts of Nilphamari district. A mixed mode study design including both quantitative survey and qualitative methods such as focus group discussions (FGDs), key informant interviews (KIIs), and field observations was employed. Household survey was employed through one-on-one interviews and data regarding farmers' perception, socioeconomic attributes of the farmers were collected. Data gathered using the qualitative methods were utilized to prepare the survey instrument and also to support the study findings.

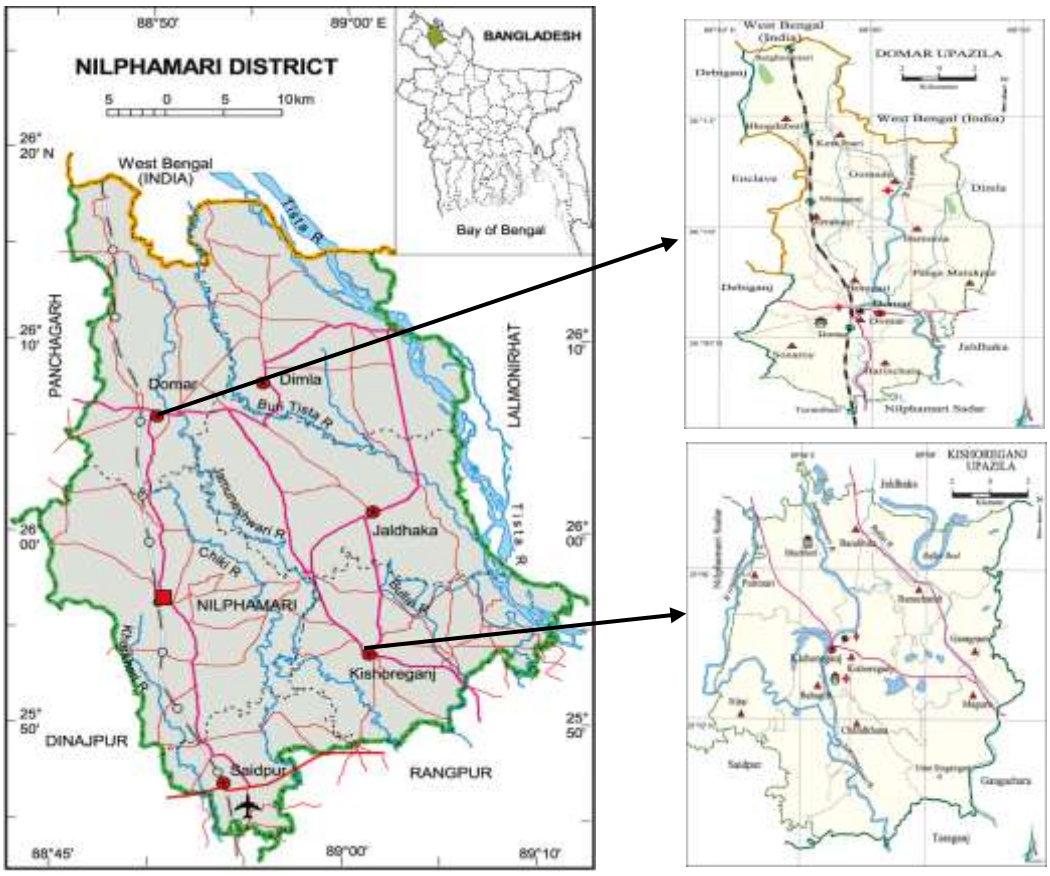

Figure 1. Map showing study areas

Sampling, data collection and analysis

Smallholder farmers engaged with crop production were considered as the population of the study. Lists of the smallholder farmers were collected from the agriculture office of the respective sub-district of Nilphamari district. A total of 39,342 smallholder farmers were identified in the study areas. According to Israel (1992), the ideal sample size for a population of 39,342 with 95 percent confidence interval and 10 percent level of precision (sampling error) is 100. A total of 100 smallholder households were randomly determined for the survey so that each household can get the equal chance to participate in the survey. Before going to the final survey, pre-testing of the survey instruments was employed 15 smallholder farmers. Final data were collected through household survey during September and October 2017.

The explanatory variables of the study were eight (08) socio-economic characteristics of smallholder farmers, viz., age, year of schooling, household

size, farm size, farming experience, annual income, access to information source and training experience. Explanatory variables were measured according to raw data by developing and using appropriate scale (Table 1).

A Likert scale was used to determine the smallholder farmers' perception to climate change impact on crop production. Twelve statements were obtained from FGDs and incorporated into the scale. The farmers were asked to provide with their extent of agreement for each statement against five possible responses, such as, strongly agree, agree, undecided, disagree and strongly disagree with a corresponding score of 5, 4, 3, 2, and 1, respectively. Therefore, the scale score varied from 12 to 60, where 12 indicated no impacts and 60 indicated severe impacts. A perception index (PI) was measured to find out the most important impact of climate change on crop production by using the following formula (Equation 1).

$$\text{Perception Index (PI)} = (SA \times 5 + A \times 4 + U \times 3 + D \times 2 + SD \times 1)/N \quad \ldots\ldots (1)$$

Where,

SA= frequency of response with strongly agree, A = frequency of responses with agree, U = frequency of responses with undecided, D= frequency of responses with disagree, SD = frequency of responses with strongly disagree, N = total frequency of responses

The survey data were scrutinized, coded and analyzed suing the statistical package for social science (SPSS) version 16. Microsoft excel 13 was used to prepare different charts or graphs based on the nature of data. Pearson Product Moment Correlation Coefficient (r) also employed to determine the relationship between focus and explanatory variables. In addition, multiple linear regression and stepwise regression were used to determine the factors affecting smallholder farmers' perception to climate change impact on crop production.

Results

Socio-economic characteristics of the smallholder farmers

Socio-economic characteristics of smallholder farmers are shown in Table 1. Findings show that most of the respondents of the study area were middle aged (42 percent). Majority (37 percent) of the respondents did not attend any formal schooling. A 71 percent of respondents had small household size and 60 percent had 0.21ha to 0.47 ha of land holdings with an average value 0.484 ha.

Table 1. Socio-economic characteristics of the respondents (n=100)

Characteristics	Category	Frequency	Percentage	Mean	SD*
Age (year)	Young (up to 35)	29	29	44.15	12.147
	Middle aged (36-50)	42	42		
	Old (above 50)	29	29		
Year of schooling	No formal	37	37	4.77	4.485
	Primary (1-5)	23	23		
	Secondary (6-10)	30	30		
	Higher education (above10)	10	10		
Household size (number)	Small (1-5)	71	71	5.11	2.093
	Medium (6-10)	26	26		
	Large (over 10)	3	3		
Farm size (ha)	0.21-0.47	60	60	0.484	0.276
	0.48-0.71	16	16		
	0.74-1.0	24	24		
Farming experience (year)	Low (up to 20)	39	39	26.74	12.903
	Moderate (21-40)	49	49		
	High(over 40)	12	12		
Annual income (000'BDT)	Up to 120	57	57	124624.90	80564.43
	121-210	23	23		
	Above 210	19	19		
Access to information sources (score)	Low (up to 10)	38	38	13.51	6.514
	Moderate (11-20)	43	43		
	High (above 20)	19	19		
Training experience (days)	No training (0)	85	85	15.33	20.607
	Low (1-30)	12	12		
	Moderate (31-60)	3	3		

* SD = Standard Deviation; BDT = Bangladeshi Taka

The data also showed that around half of the respondents had moderate farming experience followed by low experience (39 percent) and annual income of more than half of the respondents was less than Tk. 121.0 thousand. About 43 percent of the respondents had moderate access to information sources followed by low access (38 percent). More than four-fifth of the respondents (85 percent) did not receive any training.

Perceived impact of climate change on crop production

A Likert scale was used to find out smallholder farmers' perception to climate change impact on crop production. Twelve statements obtained from

FGDs were incorporated into the scale. A score was obtained on the scale, which ranged from 12 to 60. Based on the perception score, smallholder farmers were classified into three categories as shown in Table 2.

Table 2. Distribution of the respondents according to the perceived impact of climate change (n=100)

Category	Number	Percentage	Mean	SD*
Low impact (up to 28)	0	0		
Moderate impact (29-44)	43	43	45.84	3.989
Severe impact (above 44)	57	57		

* SD = Standard Deviation

Data in Table 2 showed that majority of the respondents (57 percent) perceived that climate change had severe impact on crop production. Rest of the respondents (43 percent) perceived moderate impact on crop production and no farmer (0 percent) reported low impact of climate change on crop production.

A perception index (PI) was employed to rank individual statement according to their perceived importance by the respondents (Table 3). The farmers identified increased pest infestation as the most important impact of climate change with a PI of 4.59.

Table 3. Rank order of individual impact of climate change as perceived by the respondents (n = 100)

Statements	Nature of Agreement					PI	RO
	SA	A	U	D	SD		
Pest infestations has been increased	64	32	3	1	-	4.59	1
Intensity of droughts have been increased	55	44	-	1	-	4.53	2
Climate change influence crop production	57	29	1	13	-	4.30	3
Irrigation water is not sufficient for crop production	37	49	13	1	-	4.22	4
Late rainfall influence crop production	21	74	4	1	-	4.15	5
Dry spells impede crop production	36	40	23	1	-	4.11	6
Crop productivity has been reduced	20	66	8	6	-	4.00	7
Soil fertility has been reduced	10	76	3	11	-	3.85	8
Planting time has been changed	-	42	30	27	1	3.13	9
Crop area has been reduced	1	40	27	29	3	3.07	10
Intensity of river bank erosions have been increased	2	35	25	32	6	2.95	11
Intensity of floods have been increased	1	40	15	40	4	2.94	12

Code: SA (Strongly Agree) =5, A (Agree) = 4, U (Undecided) = 3, D (Disagree) = 2, SD (Strongly Disagree) = 1, PI = Perception Index, RO = Rank Order

Increased intensity of droughts was found as second most important impact with a PI of 4.53 as perceived by the respondents. Climate change

influenced crop production (PI = 4.30) was ranked as third important impact as perceived by the respondents. However, increased intensity of floods (PI = 2.94) was perceived as least important impact of climate change on crop production.

Correlation between socioeconomic characteristics and farmers' perception

A null hypothesis (H_0) was formulated to determine association between explanatory variables and the focus variable, i.e., perception to climate change impact on crop production. H_0 indicated that there is no association between explanatory and focus variables. Pearson product moment coefficient of correlation (r) was employed to explore the association, where a five percent level of probability was used to reject the H_0. A summary of the test is shown in Table 4.

Table 4. Correlation between explanatory and focus variables (n=100)

Socio-economic characteristics	Correlation co-efficient (r)	Tabulated value of r	
		0.05	0.01
Age	0.202*		
Year of schooling	0.280**		
Household size	0.001		
Farm size	0.036		
Farming experience	0.198*	0.197	0.257
Annual household income	0.019		
Access to information source	0.259**		
Training experience	0.276**		

df (degrees of freedom) = 98; **Correlation significant at the 0.01 level (2-tailed). *Correlation significant at the 0.05 level (2-tailed).

Table 4 indicates that out of eight explanatory variables, age, year of schooling, farming experience, access to information sources and training experience had significant and positive association with the smallholder farmers' perception to climate change impact on crop production.

Stepwise multiple regression analysis

A stepwise multiple regression analysis was employed to understand individual contribution of the explanatory variable to the variation of smallholder farmers' perception to climate change impact on crop production. Table 5 represents the summary of the stepwise multiple regression analysis.

Table 5. Summary of the stepwise multiple regression analysis (n = 100)

Model	Coefficient of determination (R)	Multiple R^2	Change in R^2	Variation explained (percentage)	Significance level
Constant+X_2	0.280	0.078	0.078	7.8	0.005
Constant+X_2+X_5	0.354	0.126	0.047	4.7	0.001
Constant+X_2+X_5+X_8	0.402	0.162	0.036	3.6	0.001

Variables entered: Year of schooling (X_2), Farming experience (X_5), Training experience (X_8)

Table 5 indicates that three variables such as year of schooling, farming experience and training experience comprised the model and they together (R2 = 0.162) explained 16.2 percent variation in the farmers' perception to climate change impact on crop production. The first variable entered into the model was year of schooling (R2 = 0.078), which made the highest contribution (7.8 percent) in explaining the focus variable. The second variable entered into the model was faring experience and it was found to contribute 4.7 percent in explaining the variation of the focus variable. The third variable was training experience and it contributed 3.6 percent in explaining variation in the focus variable.

Discussion

It is found that majority of the respondents in the study area were in middle aged group. Middle aged and old farmers were found as more experienced and aware of climate change and its impacts on crop production (Ishaya and Abaje, 2008). It was noticed that majority respondents did not have formal schooling. Education helps farmers to access diversified information sources that enables them to a better perception to climate change impacts (Habiba *et al*., 2014). Larger farm size influences the farmers to access more information regarding climate change impacts and technology adoption (Daberkow and McBride, 2003). However, it was found that more than half of the respondents (60 percent) had only 0.21-0.47 ha of land. Farmers with more farming experience are likely to be more aware and to have better understanding about climate change and farm related decision making. In addition, family income is also found to be a key factor in farming decisions (Habiba *et al*., 2014). Information sources can play a great role in farm management decision of any type. Access to sufficient training enables farmers to understand climate change and its impact on crop production along with necessary farm adjustments. The findings may be due that smallholder farmers were usually subsistence farmers, they rather like to work in their farms and

could perceive that participation in organization was time and resource consuming.

It can be seen that the study area experiences moderate to severe impacts of climate change on crop production. Increased temperature, uneven and off season rainfall leading to drought occurrences could be the key reasons for the findings. The agriculture in the study area is mostly rice based along with vegetables and some fruit crops. Therefore, climate change could directly influence the crop production due to its nature. Majority of the FGD participants reported - we cannot transplant rice timely because of unavailability of irrigation water, rather we have to bear a significant amount costs in getting irrigation water for crop production.

From the perception index, we can see that increased pest infestation was most significant impact of climate change on crop production. Hot and humid weather is congenial for pest outbreaks. The study area was typically a drought prone area, where increased temperature could be reason for pest infestation. Akanda and Howlader (2015) reported increased temperature and diseases due to climate change in their study. Continuous less and uneven rainfall could be reason for increased intensity of droughts in the study area. Due to low and erratic rainfall, we cannot rely on surface water but groundwater, and during the peak growing season droughts come out- FGD participants. Islam and Hossen (2016) reported decreased source of water as most perceived impact of climate change. Drought frequency, due to insufficient rainfall, and increased evaporation lead to complete crop failure (Liu *et al*., 2010). Crop production system directly depends on climatic condition (Sikder and Xiaoying, 2014), and hence, little changes in the climatic pattern can bring impact on crop production. Sikder and Xiaoying (2014) stated that warming caused by climate change lowers crop production. Due to climate induced increase in temperature, untimely precipitation, droughts, floods and salinity rice production was adversely affected (Rimi *et al*., 2009). This clearly employs that low rainfall during the rainy season could be responsible for this finding. In the recent years, there is no rainfall even in the rainy season, consequently, canals and lakes remained dry and hence, we cannot see floods as earlier- FGD participants. Ghosh *et al*. (2015) reported a decrease in rainfall in their study in drought prone areas.

The findings demonstrate that old aged farmers were likely to perceive climate change impacts on crop production more efficiently. This could be due to that aged farmers through their experience could predict their farms and take necessary decisions to address the problems. Huda *et al*. (2016) found significant and positive correlation between age of the farmers and agricultural adaptation strategies to climate change. Mardy *et al*. (2018) reported similar

finding in their study. Education helps a person to be more aware, knowledgeable and broaden their outlook about regarding farming and other issues. With the increase of year of schooling, an individual become able to realize the impacts and consequences of climate change. Islam and Hossen (2016), and Akanda and Howlader (2015) also found that education is positively and significantly associated with farmers' perception in their respective study. Mardy *et al*. (2018) reported a significant and positive association between education and adaptation to climate change. Access to various information sources helps a person to be smart and wise. They can come across and consult different farm related issues that help them taking suitable adjustments. Through participating in different training programmes individual can secure information about crop production and the impact of climate change on it.

Stepwise regression implies that with the increase in educational level, the smallholder farmers' perception increases. Farmers with high level of formal schooling possess significant knowledge about their farms and farm problems as they can have access to a wider range of information sources (Uddin *et al*., 2014). Increased farming experience of the smallholder farmers enhances their level of perception. Farmers with high farming experience can predict their farms and related issues. They also become able to address farm problems regarding climate change and make suitable adjustments. The finding also shows that training exposure enhances famers' ability to perceive the impact of climate change on crop production. Farmers in the training programmes learn the know-how and do-how of certain farm activities. Farmers with high training exposure are likely to have more ability to manage their farms as well as to predict climate change impacts on crop production.

Conclusion

From the discussions above, it is evident that the smallholder farmers in the study area percieve severe impacts of climate change on crop production. This issue really urges some sorts of programme in order to address and provide suitable solutions to the farmers. A number of impacts the smallholder farmers experience in the study area, and pest infestation, water scarcity during the peak growing seasons needs some immediate solutions for the betterment of them. Research on adaptation to climate change by the smallholder farmers could bring some appropriate findings and recommendations for the studied area. In addition, government could take initiatives to provide some logistic supports such as pesticide sprayers, easy access to electricity and subsidized shallow or deep tube wells in the study area. Socio-economic characteristics

such as formal schooling, farming experience and training experience were found most important factors that affect farmers' perception to climate change impacts. Therefore, programmes focusing on these factors could probably enhance farmers' perception and adaptation capacities to climate change impacts. Finally, an amalgamated approach including both government and private extension providers could significantly play roles in addressing the mentioned issue.

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